Past penguin colony responses to explosive volcanism and climate change on the Antarctic Peninsula

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Warming and reductions in land- and sea-ice in some parts of the Antarctica Peninsula (AP) in recent decades are having a negative impact some penguin species (e.g., Adélie) by altering access routes to breeding sites and shifting the location of northern AP shelf-edge krill spawning grounds. Meanwhile, populations of gentoo penguins, which are generalist, inshore predators and prefer to breed in ice-free areas, have remained stable or increased.

Over the last 30 years, the largest breeding population of gentoo penguins in Antarctica on Ardley Island, north-western AP, has increased by c. +300% to more than 5,000 breeding pairs. Intriguingly, genetic, sub-fossil and biogeochemical studies have shown that species-specific population trends across the AP in recent decades are different from those of previous warm-periods, but also that the response of gentoo penguins to warming has been consistently positive (Clucas et al., 2014; Emslie et al., 2014). To test this hypothesis further, we used biogeochemical analysis of penguin guano in lake sediments to track past changes in penguin colony size on Ardley Island over the last 8,500 years. We then compared this data with *in-situ* sub-fossil records of penguin presence and records of past climate, sea-ice extent and volcanic activity from across the Antarctic Peninsula. Results show that after deglaciation, c. 8,500 years ago, the first sustained penguin colony was established on Ardley Island c. 6,700 years ago, pre-dating previous sub-fossil evidence of Peninsula-wide occupation by c. 1,000 years. The Ardley Lake penguin colony experienced five population maxima during the mid-late Holocene, responding most positively c. 4,000-3,000 years ago during a well-defined regionally-warmer phase of the late Holocene.

However, we find no statistically-consistent relationships with local-regional atmospheric and ocean temperatures or sea-ice conditions for the mid to late Holocene as a whole. This is because three of the five phases of penguin colony expansion were abruptly ended by the deposition of volcanic ash from large volcanic eruptions from nearby Deception Island. Sustainable post-eruption colony recovery took, on average, 400-800 years, but was particularly slow following the most disruptive phase of volcanic activity that began c. 5,500 years ago. We are currently investigating whether biomarker and environmental DNA analysis of lacustrine sediments provides a reliable archive of past penguin presence and if past changes in penguin species distribution can be reconstructed (e.g., Fernandez-Carazo et al., 2013).

References

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